The heavy rains that fell over eastern Texas from the 15th to the 20th, inclusive, were followed by moderate floods in the rivers of that district, except in the Neches, and the upper portions of the Brazos and Colorado rivers. Flood stages were exceeded, but not to any decided extent, except in the valley of the Guadalupe and lower Colorado rivers, where the rains had been heavier, resulting in stages from 7 to 10 feet above the flood stages. Warnings were issued regularly from the 18th until the 20th, inclusive, and no reports of damage or loss have been received. The rivers of the Pacific States were quiet.

The highest and lowest water, mean stage, and monthly range at 197 river stations are given in Table VI. Hydrographs for typical points on seven principal rivers are shown on Chart I. The stations selected for charting are Keokuk, St. Louis, Memphis, Vicksburg, and New Orleans, on the Mississippi; Cincinnati and Cairo, on the Ohio; Nashville, on the Cumberland; Johnsonville, on the Tennessee; Kansas City, on the Missouri; Little Rock, on the Arkansas; and Shreveport, on the Red.—*H. C. Frankenfield, Professor of Meteorology.*

* Morning forecasts made at district center; night forecasts made at Washington, D. C.

† Morning and night forecasts made at district center.

SPECIAL ARTICLES, NOTES, AND EXTRACTS.

PHENOMENA CONNECTED WITH THE SAN FRANCISCO EARTHQUAKE.

By Dr. C. M. RICHTER and Prof. ALEXANDER G. MCADIE. Dated San Francisco, Cal., December 28, 1907.

A number of phenomena have been reported in different publications (Science, Nature, Gaea, and others), as observed during and after the earthquake of April 18, 1906, which it seems to us need more accurate description and a statement of the facts as we know them, who were present at the time and made notes of them.

First, we may call attention to earthquake sounds. Such sounds were reported by many people after the earthquake. Many claim to have heard a sound comparable to an approaching windstorm or the roll of a heavy wagon; but in our judgment most of these sounds can be explained by the noise due to violent shaking of dwellings. There are, however, some reports of a sound like that of a violent wind preceding the first shake. We have no record of any detonation coming from the ground.

With regard to light and fire phenomena a number of statements have been made, many of which have been shown to be erroneous by "D. S. J." in Science.[1] Some of the most elaborate and detailed statements of such phenomena were given by those who were not in San Francisco during the earthquake.

We have no proof whatever that any particular optical or electrical phenomenon occurred preceding, during, or following the earthquake. The atmospheric conditions preceding and at the time of the earthquake are described in the report of the California section of the Climatological Service of the Weather Bureau for April, 1906. This report states:

> The morning of Wednesday, April 18, was clear and pleasant over the greater portion of the Pacific coast. An area of high pressure was moving steadily and somewhat slowly eastward over Idaho. The weather map gives the conditions existing a few minutes previous to the great earthquake, and it may be noted that the pressure distribution is of a type that has been found to prevail when certain earthquakes occur in California. A study of the relation of atmospheric pressure and earth movement had been under way in the office of the Weather Bureau at San Francisco for some years, and while no very definite conclusions had been arrived at it was plain that the greater number of earthquakes in California occurred apparently without any relation to pressure distribution. It was noticed, however, that some earthquakes occurred during the passage of a marked high across the northern portion of the coast. While any relation of this character must be obscure and indefinite, it is conceivable that in a region where quakes and tremors of tectonic origin are frequent—i. e., a region where strata are in unstable equilibrium—the passage of an area of high pressure may directly or indirectly affect the stresses at critical times. The relation is involved and is alluded to here only because at Manila and Tokyo microseismic phenomena bear some relation to approaching typhoons. The thought suggests itself that the installation of seismographs on the Pacific coast may lead to the detection of advancing pressure areas.

A. Sieberg[2] asserts that "die Erdbeben die örtliche witterung nicht beeinflussen", and later[3] "Die Luftdruckschwankungen vermögen den Eintritt von Dislokationsbeben zu fördern". His material would rather favor a falling barometer as a causative factor. At the time of the San Francisco earthquake there was a well-defined high over practically the entire area of the United States. Similar barometric conditions had occurred at the beginning of April and at other times. The high of April 18 had no unusual characteristics.

Much has been said by various reporters about the high winds and marked indrafts of air due to the fire. It has been said that the strong winds caused by the fire were felt miles at sea. Concerning this, the best comment that can be made is that the instruments of the Weather Bureau were in place thruout the entire day of April 18. The Weather Bureau records are continuous up to 5 p. m. of the 18th, or, in other words, for a period extending thru the earthquake and twelve hours after the earthquake. These records are available, and show that there were no unusual features connected with air motion. The wind had been westerly on April 17, with a velocity of 14 miles an hour, the sky clear and the weather pleasant. A few minutes preceding the earthquake the wind was from the west, velocity 3 miles per hour, weather clear. At 5 p. m. of the 18th the pressure, reduced to sea level, was 30.15 inches; the temperature of the dry-bulb thermometer, 61.8° F., of the wet-bulb thermometer, 54.0°; and the direction of the wind, west, the velocity, 22 miles an hour. In brief, then, there was nothing remarkable in a meteorological way during the twenty-four hours under consideration. It was a pleasant spring day.

Some reports have been published concerning unusual clouds formed early during the fire and described as caused by the fire. One of the writers of this article photographed the smoke cloud as early as 8 a. m., that is to say, less than three hours after the beginning of the fire. These clouds were also carefully observed by observers of the Weather Bureau. They were, so far as we could determine, purely smoke masses, and the general elevation of the top of these clouds was probably not above 500 feet. Certain peculiarities have been reported concerning these clouds.[4] Except for their size and density, we who closely observed these appearances at the beginning and during the whole period of the fire remember seeing nothing that can not be explained as smoke effects, such as a large fire would cause. While the appearance of the smoke at different hours was interesting, there was no unusual or phenomenal cloud development. So far as we could determine, there was no marked indraft of air caused by the intense heat. The lower air movement agreed with the usual movement due to the passage of an area of high pressure, the light north and northeast winds giving way to moderately strong west winds. It was apparently this change that prevented the complete destruction of San Francisco by fire.

There was no tidal wave or unusual disturbance in the Bay of San Francisco. As a matter of fact, the waters of San Francisco Bay were unusually calm on April 18, before, during and after the earthquake. In this connection it might not be

[1] Issue of August 10, 1906.

[2] Handbuch der Erdbebenkunde, 1904, p. 124.

[3] Ibid., p. 126.

[4] See Science, November 14, 1906; Nature, vol. 74, 1906, p. 133; also Science, April 5, 1907, p. 554.

out of place to note that Prof. George Davidson has corrected a statement published in the description of the earthquake at San Francisco on February 18, 1856, where one writer states that "the water in the Bay of San Francisco rose, maintained its level for five minutes, and then sank 2 feet below its ordinary stage". Professor Davidson obtained a tracing of the mareograph from the Coast Survey, and this shows that the trace of the water level was remarkably smooth on the date in question.

Presentiments of the earthquake have been reported by reliable witnesses. Many people have stated that they past a restless night preceding the earthquake and were awake some hours before the earthquake occurred. Reports were also made of unusual manifestations made by animals. Our explanation of such conditions is that sleeplessness or unusual manifestations of the nervous system are not infrequent in California during the passage of a well-marked area of high pressure accompanied by low relative humidity and northerly winds.

Incidentally we may mention that the Weather Bureau records were faithfully and regularly made on April 18, the day of the earthquake. The great shock was at 5:13 a. m., and the Weather Bureau records are complete up to 5 p. m. of that day. The building caught fire on the evening of April 18. We lost three observations during the three days' fire, namely, a. m. of the 19th, p. m. of the 19th, and a. m. of the 20th. Our records begin again about noon of the 20th, while the fire was still raging.

THE CHRISTMAS SNOWSTORM OF 1906.

By HUGH ROBERT MILL, Director of the British Rainfall Organization, 62 Camden Square, London, NW.

[Reprinted from British Rainfall, 1906.]

By Christmas eve 3,521 circulars containing forms for recording the rainfall of 1907 had been prepared for posting, tied up in bundles of 60 each, and left ready at 62 Camden Square, to be sent to the post-office on the appointed day. The assistants had left for their short and well-earned holiday, and there seemed to be a week of comparative leisure before us. On the morning of Boxing Day (1906) the whole neighborhood of London was found covered with 4 or 5 inches of snow, which had come down in the night, and at Mill Hill the circumstances were so interesting that we resolved to make a special and detailed investigation into the storm, if so soft and silent an envelopment could be called by such a name. The night of the 25th had been fine and star-lit, with white clouds appearing about 10 p. m. in the southwest, and at 11 p. m. no snow or rain was falling. Next morning, at 7 o'clock, the sky was blue and clear, the wind blowing cold as a light breeze from the northeast, and grass and trees were covered alike with a snowy fleece. There had evidently been a fierce wind in the night, for the snow was drifted deeply against walls and hedges, and plastered thickly on the southwestern sides of trees and walls; the northeastern sides were entirely clear, showing that there had been a shift of the wind to a diametrically opposite quarter since the drifting ceased.

Next morning the newspaper reports showed that the snowfall had been very widespread, and we sent the accompanying form[1] to the printer, in order to give all rainfall observers an opportunity of recording their experiences. By the evening the first batch of copies was received. It took the evening of the 27th and nearly all day on the 28th to get the 3,000 ungummed envelopes loosened from their bundles, opened, the slips inserted, and the envelope flaps tucked in and made up again in bundles of 60. The 521 packets in closed envelopes for those observers who report monthly could not be dealt with in this way, so snow circulars for that number had to be separately addressed; but at length they were completed and dispatched just before the closing time of the post-office on the 28th.

The number of slips which returned to us with information was 1,862, and we must regretfully acknowledge that we have not been able to do more than touch upon some salient lines of the information they contained. All are preserved, and we hope they can be further utilized. The storm was not the isolated phenomenon which the first newspaper reports had led us to expect. It was followed for several days by snowy conditions, and it was soon apparent that during the last week of the year there were two separate snowstorms, one on the 25th and 26th, which affected the west of Scotland and the whole of England, except the northeast, gently and with little inconvenience; and another on the 27th and 28th, which was very severe indeed in the east of Scotland, in Ireland, and the southwest of England. In parts of Yorkshire and the border counties both storms appeared, and in some of these places it is difficult to distinguish between them. The second storm was accompanied by strong electrical disturbances and a severe gale, so that the light, powdery snow was driven into enormous drifts, causing much distress to farm and village dwellers in Aberdeenshire and adjacent counties. Aberdeen itself was cut off for several days from telegraphic and railway communication with the rest of the country. A terrible railway accident occurred in the thick of the storm at Elliott Junction, near Arbroath, causing loss of life, and the storm was in every way one of the severest on record.

After a cursory examination of the returns, and the elimination of those the statements on which were too vague to be useful, we decided to deal only with the first storm, and to limit our work to a consideration of the depth of snow over the country and the hour at which the snowfall commenced. This storm was by no means the severest, and perhaps not the most widespread, in recent years; but the great quantity of data obtained from skilled observers makes it possible to deal with it more exactly than has ever been practicable before.

We have made many maps of heavy falls of rain, but it is a very difficult thing to map a light fall, on account of the uncertainty as to the date of entry by observers who do not consistently follow the rule. In the case of a heavy fall, the individuality of the day is so well marked that those who enter to "wrong day" are immediately detected. A fall of snow is much more conspicuous than a shower of rain, and estimates of the depth of snow, though individually less accurate than measurements of the fall of rain, may collectively give a good general account of what is equivalent to a light shower; hence one part of the value of studying snowfall.

Care was taken first to eliminate those returns which lumped together the snowfall of several days, and all the figures which belonged to the period 25–26th were plotted on a map on the scale of about 20 miles to an inch. The error in measuring snow may lead to over or under estimates, for drifting increases the depth in some places and diminishes it in others; hence it is to be expected that large figures will sometimes be found amongst a group of small values, and that a few small figures will be found in the midst of an overwhelming crowd of larger. But when, as in this case, the figures are very numerous it is easy to see and to ignore the minority of dissentient values, be they too high or too low, and we found it possible by following the majority to prepare a very serviceable map of the depth of snow on the day in question. This map we reproduce on a reduced scale (fig. 1). It shows in solid black those parts of the country where no snow fell; but there was precipitation on that day in the form of rain over the western areas at least, where the temperature did not admit of the formation of snow. The area of the snowfall is seen to be a zone (150 miles broad in the north and widening to 200 miles in the south) stretching from northwest to southeast from the north of Ireland and west of Scotland to the English Channel

[1] Omitted in this reprint.—EDITOR.